like infra-red sensor scans). Both types of data are needed for a large area surrounding and including the area of interest in order to deduce the current weather conditions and predict changes. To obtain these real-time data, the earth station must be located in or near the area of interest, which enables reception of data from the satellite when it is observing the area of interest and surrounding areas and it is located at high elevation angles from the earth station (e.g., above 25 degrees, which was a design objective NOAA's Automatic Picture Transmission (APT) downlinks at 137-138 MHz). Under these conditions at mid-latitudes, a constellation of two meteorological satellites would provide useful data from about seven satellite passes per day lasting about nine minutes per pass, on average. The data received from these passes is sufficient to cover the areas surrounding the earth station at time intervals that are small enough to establish correlations between observations, which enables local forecasting to be accomplished.

Conversely, if the receiving earth station were located at a large distance from the area of interest, the satellite is visible only at low elevation angles. The time intervals between satellite passes covering the distant area of interest are relatively long, which substantially reduces the reliability of forecastings. Furthermore, the amount of data obtained for the area of interest often is too limited to infer current weather conditions, and no data are obtained for more distant areas. In the extreme case, when viewed at elevation angles between zero (0) and five (5) degrees, the meteorological satellite is observing areas located between 3,091 km (1,932 miles) and 2,576 km (1,610 miles) from the receiver location. Only two to four satellite passes per day will cover an area so far away, and the durations of satellite visibility events will often be less than two minutes (depending on the orientation of the receiver and the area of interest). Consequently, real-time data associated with receiver antenna elevation angles less than five degrees generally is not useful. There are many applications, however, where meteorological data are required for far-distant areas. These data are obtained either via communications links with receiving earth stations that are proximate to the area of interest, or from playback of data that were collected and recorded by a satellite passing over the area of interest (e.g., Command and Data Acquisition (CDA) transmissions in the 1698-1710 MHz band).

B. PERFORMANCE LIMITATIONS GENERALLY PRECLUDE OPERATION AT ELEVATION ANGLES LESS THAN FIVE DEGREES

Signal propagation phenomena occuring at low elevation angles prevent satisfactory recovery of data, as can be seen in the link power budgets presented in Tables 1 and 2 for reception at 137-138 MHz and 400.15-401 MHz, respectively.[2] Specifically, the link power margins (last row of the tables) indicate that typical earth stations often cannot receive useful data at elevation angles of five (5) or less. As explained further below, debilitating signal losses occur with high probability at low elevation angles due to multipath fading and atmosheric refraction. The magnitude of these losses vary greatly over time as the elevation angle changes; the values for these losses included in Tables 1 and 2 are expected values.[3]

1. Surface Multipath Effects

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[2] The parameters given in Tables 1 and 2 for NOAA and DMSP satellites and typical earth stations are taken from Recommendations ITU-R SA.1025-1 ("Performance Criteria for Space-to-Earth Data Transmission Systems Operating in the Earth Exploration-Satellite and Meteorological-Satellite Services Using Satellites in Low-Earth Orbit") and ITU-R SA.1026-1 ("Interference Criteria for Space-to-Earth Data Transmission Systems Operating in the Earth Exploration-Satellite and Meteorological-Satellite Services Using Satellites in Low-Earth Orbit"). These parameters are identical to the parameters supplied in US contributions to the April 1993 meeting of ITU-R Working Party 7C.

[3] As the satellite ascends above the horizon and the elevation angle increases, the received signal amplitude and phase and its polarization fluctuates as the desired and multipath signal path geometries vary. At certain elevation angles in the range of zero (0) to five (5) degrees elevation, the multipath losses will be substantially higher than the expected values shown in Table 1, depending on geometric and radio parameters associated with the local environment and the earth stations.

The signal received from a satellite at a low angle of elevation consist of three components: (1) a signal that travels over the direct path from the satellite to the earth station (i.e., a line-of-sight path); (2) a coherent, time-shifted replica of the signal travelling over a reflection path (i.e., the specular component of multipath); and (3) multiple, time-shifted replicas of the signal that have been scattered by the Earth surface and proximate objects (i.e., the diffuse component of multipath).[4] The signals received from the multipath signal propagation mechanisms have time-varying amplitude and phase, and interfere with the direct signal in a manner referred to as multipath fading. At low elevation angles, the receiver antenna provides no significant discrimination against multipath signals, which are co-polar with the desired "direct" signal (i.e., reflection and scattering does not alter polarization orientation at grazing angles less than the Brewster angle (generally greater than six (6) degrees over land)). Thus, receivers are susceptible to the severe multipath fading that occurs at low elevation angles. The magnitude of these surface multipath signals depends on electrical characteristics of the scattering and reflecting surfaces and the signal grazing angle. Mulipath fading cannot be remedied with increased transmission power from the satellite because this equally increases the power in both the line-of-sight and interfering multipath signals.

Table 3 shows the statistics of multipath fading and underlying parameters for typical meteorological earth stations operating on medium dry ground, as determined using the method of CCIR Report 1008-1 (1990). The calculated carrier-to-multipath power ratio (K) values were

[4] Atmospheric multipath occasionally compounds the fading arising from surface multipath, but this degradation is disregarded in this analysis. Atmospheric multipath occurs uniquely at low elevation angles during certain atmospheric conditions that generally exist for less than 10% of the time.

used with the Nakagami-Rice distribution of the composite received signal power to obtain the cumulative time statistics of multipath fading. For elevation angles varying between zero (0) and five (5) degrees, the 80%ile values of multipath fading are the expected values.

2. Atmospheric Refractive Losses

At elevation angles less than three (3) degrees, the refractive gradient of the atmosphere exacerbates the theoretical free space spreading of the satellite signal. In effect, increased signal spreading occurs in the vertical direction at low elevation angles, which is the same phenomena that distorts the apparent shape of the sun during sunrise and sunset. The average values for this loss included in Tables 1 and 2 are taken from Section 4.2.4 of the ITU Handbook on Radiometeorology (Geneva, 1996).

C. A FIVE DEGREE MINIMUM ELEVATION ANGLE IS SPECIFIED WITH THE APPLICABLE PERFORMANCE AND PROTECTION CRITERIA

In light of the above functional requirements and performance limitations, the performance and interference criteria adopted internationally for meteorological satellite services are specified for elevation angles of five (5) degrees and higher. Specifically, for the 137-138 MHz and 400.15 - 401 MHz bands, Recommendation ITU-R SA.1025-1 specifies meteorological satellite performance objectives for 99.9% of the time that the elevation angle exceeds five (5) degrees. For protection of these transmissions, Recommendation ITU-R SA.1026-1 specifies that the total interfering signal power should not exceed certain levels during reception at elevation angles exceeding five (5) degrees. Both of these Recommendations were based on United States input documents to the ITU Working Party 7C, which were endorsed by the worlds meteorological satellite experts.

TABLE 1a

Link Power Budgets for Automatic Picture Transmission (137 - 138 MHz)

Elevation Angle	5°	4°	3°	2°	1°	0°
Satellite antenna input power (dBW)	4.9	4.9	4.9	4.9	4.9	4.9
Satellite antenna gain (dBic)	0.7	0.7	0.7	0.7	0.7	0.7
Satellite e.i.r.p. (dBW)	5.6	5.6	5.6	5.6	5.6	5.6
Free space loss (dB)	144.3	144.5	144.8	145.1	145.4	145.7
Surface Multipath (dB)(80%ile)	1.9	2.1	2.6	3.2	4.6	5.9
Refractive spreading (dB)(50%ile)	0.1	0.2	0.3	0.4	0.8	2.7
Earth station antenna gain (dBic)	2	2	2	2	2	2
Antenna mispointing loss (dB)	0	0	0	0	0	0
Polarization mismatch loss (dB)(50%ile)	1.5	1.5	1.5	1.5	1.5	1.5
Modulator and demodulator losses (dB)	2	2	2	2	2	2
Receiver reference bandwidth (kHz)	50	50	50	50	50	50
Data rate (dB Hz)	45.7	45.7	45.7	45.7	45.7	45.7
Received energy per bit (dBW/Hz) E_b	-187.9	-188.4	-189.3	-190.3	-192.4	-195.9
Receiver system noise temperature (K)	2520.	2520.	2520.	2520.	2520.	2520.
Thermal noise power density (dBW/Hz)	-194.6	-194.6	-194.6	-194.6	-194.6	-194.6
Non-thermal receiver noise power density (dBW/Hz)	-300.	-300.	-300.	-300.	-300.	-300.
Total internal noise power density (dBW/Hz) N_o	-194.6	-194.6	-194.6	-194.6	-194.6	-194.6
Threshold E_b/N_o (dB)	12.	12.	12.	12.	12.	12.
Power margin (dB)	-5.4	-5.8	-6.7	-7.7	-9.8	-13.3

TABLE 1b

Link Power Budgets for Low Resolution Picture Transmission (137 - 138 MHz)

Elevation Angle	5°	4°	3°	2°	1°	0°
Satellite antenna input power (dBW)	6.8	6.8	6.8	6.8	6.8	6.8
Satellite antenna gain (dBic)	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
Satellite e.i.r.p. (dBW)	5.6	5.6	5.6	5.6	5.6	5.6
Free space loss (dB)	144.3	144.5	144.8	145.1	145.4	145.7
Surface Multipath (dB)(80%ile)	1.9	2.1	2.6	3.2	4.6	5.9
Refractive spreading (dB)(50%ile)	0.1	0.2	0.3	0.4	0.8	2.7
Earth station antenna gain (dBic)	2	2	2	2	2	2
Antenna mispointing loss (dB)	0	0	0	0	0	0
Polarization mismatch loss (dB)(50%ile)	1.5	1.5	1.5	1.5	1.5	1.5
Modulator and demodulator losses (dB)	2	2	2	2	2	2
Receiver reference bandwidth (kHz)	150	150	150	150	150	150
Data rate (dB Hz)	48.6	48.6	48.6	48.6	48.6	48.6
Received energy per bit (dBW/Hz) E_b	-190.8	-191.3	-192.2	-193.2	-195.3	-198.8
Receiver system noise temperature (K)	1750.	1750.	1750.	1750.	1750.	1750.
Thermal noise power density (dBW/Hz)	-196.2	-196.2	-196.2	-196.2	-196.2	-196.2
Non-thermal receiver noise power density (dBW/Hz)	-300.	-300.	-300.	-300.	-300.	-300.
Total internal noise power density (dBW/Hz) N_o	-196.2	-196.2	-196.2	-196.2	-196.2	-196.2
Threshold E_b/N_o (dB)	6.5	6.5	6.5	6.5	6.5	6.5
Power margin (dB)	-1.2	-1.6	-2.5	-3.6	-5.7	-9.1

TABLE 2

Link Power Budgets for DMSP (400.15 - 401 MHz)

Elevation Angle	5°	4°	3°	2°	1°	0°
Satellite antenna input power (dBW)	11.1	11.1	11.1	11.1	11.1	11.1
Satellite antenna gain (dBic)	0	0	0	0	0	0
Satellite e.i.r.p. (dBW)	11.1	11.1	11.1	11.1	11.1	11.1
Free space loss (dB)	153.6	153.8	154.1	154.4	154.7	155
Surface Multipath (dB)(80%ile)	1.5	1.5	1.6	1.9	2.9	5.9
Refractive spreading (dB)(50%ile)	0.1	0.2	0.3	0.4	0.8	2.7
Earth station antenna gain (dBic)	0	0	0	0	0	0
Antenna mispointing loss (dB)	0	0	0	0	0	0
Polarization mismatch loss (dB)(50%ile)	0.3	0.3	0.3	0.3	0.3	0.3
Modulator and demodulator losses (dB)	2	2	2	2	2	2
Receiver reference bandwidth (kHz)	177.5	177.5	177.5	177.5	177.5	177.5
Data rate (dB Hz)	49.5	49.5	49.5	49.5	49.5	49.5
Received energy per bit (dBW/Hz) E_b	-195.9	-196.2	-196.7	-197.4	-199.1	-204.3
Receiver system noise temperature (K)	400.	400.	400.	400.	400.	400.
Thermal noise power density (dBW/Hz)	-202.6	-202.6	-202.6	-202.6	-202.6	-202.6
Non-thermal receiver noise power density (dBW/Hz)	-211.7	-211.7	-211.7	-211.7	-211.7	-211.7
Total internal noise power density (dBW/Hz) N_o	-202.1	-202.1	-202.1	-202.1	-202.1	-202.1
Threshold E_b/N_o (dB)	5.5	5.5	5.5	5.5	5.5	5.5
Power margin (dB)	0.6	0.4	-0.1	-0.9	-2.5	-7.7

TABLE 3

Calculations of Multipath Loss

Parameters:

E = elevation angle of the satellite (degrees), as seen from the earth station antenna;
φ = grazing angle (degrees), i.e., angle of arrival of signal at reflection area:
= in radians, E + h/(a_e + h), where "h" is the antenna height (2 meters assumed) and a_e is the radius of the Earth;
R_o = reflection coefficient for plane Earth (numerical ratio);
g = Rayleigh roughness criteria for the surface around the reflection point (numerical ratio)(standard deviation of the surface height is assumed to be 5 meters):
= $(4\pi/\lambda)(\Delta h)\sin\varphi$, where λ is the wavelength and Δh is there standard deviation of the surface height (5 meters assumed);
D = divergence factor (numerical ratio) accounting for Earth curvature:
$\approx [1 + ((2)(h)\tan E)/(a_e)(\sin\varphi)]^{-0.5}$;
ρ_s = specular reflection coefficient (numerical ratio):
$\approx [3.2X - 2 + \{3.2X^2 - 7X + 9\}^{0.5}]^{-0.5}$, where $X = 0.5g^2$;
ρ_d = diffuse scaterring coefficient (numerical ratio)(from Figure 3 of Report 1008-1);
K = ratio of direct signal power to multipath signal power (dB):
$= 10 \log [(\rho_s)^2(D)^2(R_o)^2 + (\rho_d)^2(R_o)^2]$
L(x) = propagation loss due to multipath (dB) exceeded for all but x% of the time.

Elevation Angle (E) (degrees)		0	1	2	3	4	5
φ (deg)		0	2.03	2.5	3.3	4.26	5.21
R_o		1.00	0.94	0.87	0.81	0.76	0.72
g (137 MHz)		0.00	0.50	1.00	1.51	2.01	2.51
g (401 MHz)		0.00	1.47	2.93	4.40	5.86	7.32
D		1.00	1.00	1.00	1.00	1.00	1.00
ρ_s (137 MHz)		1.00	0.88	0.64	0.43	0.31	0.24
ρ_s (401 MHz)		1.00	0.44	0.20	0.13	0.10	0.08
ρ_d (137 MHz)		0.00	0.19	0.32	0.41	0.39	0.38
ρ_d (401 MHz)		0.00	0.37	0.28	0.21	0.14	0.07
137 - 138 MHz	K (dB)	0	1.4	4.1	6.3	8.4	9.8
	L(50)	1.5	1.4	1.2	0.9	0.8	0.8
	L(80)	5.9	4.6	3.2	2.6	2.1	1.9
	L(90)	9.6	7.2	5.6	3.7	3.2	3.1
400.15 - 401 MHz	K (dB)	0	5.3	10.5	14.0	17.7	22.3
	L(50)	1.5	1.1	0.8	0.5	0.5	0.5
	L(80)	5.9	2.9	1.9	1.6	1.5	1.5
	L(90)	9.6	4.6	3.1	2.5	2.4	2.2

DECLARATION

I, Thomas M. Sullivan, do hereby declare as follows:

1. I have a Bachelor of Science degree in Electrical Engineering and have taken numerous post-graduate courses in Physics and Electrical Engineering.

2. I presently operate a consulting company, Sullivan Telecommunications Associates, and was formerly employed by the IIT Research Institute, DoD Electromagnetic Compatibility Analysis Center; the Computer Sciences Corp.; and American Mobile Satellite Corp.

3. I received in 1982 an official commendation from the Department of the Army for the establishment of worldwide frequency accommodations for mobile earth stations.

4. I am qualified to evaluate the technical information in the Comments of LEO One Corporation. I am familiar with Part 25 and other relevant parts of the Commission's Rules and Regulations.

5. I was a principal engineer in the development of the Phase A design and technical specifications of the data handling and transmission subsystems of the 137 - 138 MHz Low Resolution Picture Transmission (LRPT) system to be flown on U.S./NOAA and European/EUMETSAT satellites in low-Earth orbit before the year 2010.

6. I served as the principal engineer and author of U.S. contributions to ITU-R Working Party 7C on the performance, interference and sharing criteria of NOAA and DoD meteorological-satellite downlinks (APT, TIP, LRPT, and DMSP) operating at 137 - 138 MHz and 400.15 - 401 MHz, and I worked closely with NOAA and Air Force personnel to ensure that these contributions accurately portrayed the technical and operating characteristics of these systems.

7. I have been involved in the preparation and have reviewed the Comments of LEO One Corporation. The technical facts contained therein are accurate to the best of my knowledge and belief.

Under penalty of perjury, the foregoing is true and correct.

December 17, 1996 — Thomas M. Sullivan

Date — Thomas M. Sullivan

APPENDIX E

APPENDIX E

RESPONSES TO TECHNICAL QUESTIONS FROM NOTICE

1. Sharing with NOAA MetSat program in 137-138 MHz Band
   - A. Concurrent time sharing of TIP channels and LRPT channels.
   - B. Impact to NOAA community of Little LEO transmissions when NOAA satellites are not in view.
   - C. 48 hour reset signal is unnecessary.
   - D. MetSat Earth Stations operating at 137-138 MHz should be protected only while the associated satellites are located at elevation angles of five degrees or greater.
2. Sharing with DMSP MetSats in 400.15-401 MHz band
   - A. DMSP Earth Stations operating in the 400.15-401 MHz band should be protected only while associated satellites are located at elevation angles of five degrees or greater.
   - B. NVNG MSS System Testing Requirements
   - C. 90 Minute Command Station Requirements
   - D. Transitional Interference Statistics
     1. "CONUS" site results
     2. "Fence" site results
     3. "90 Minute" site results
   - E. Accurate Ephemeris Prediction
3. Sharing with the Radio Navigation Satellite Service

APPENDIX E

RESPONSES TO TECHNICAL QUESTIONS FROM NOTICE

1. Sharing with NOAA MetSat Program in the 137 - 138 MHz Band

The NOAA MetSat band can be shared on a non-interference basis to NOAA using a frequency avoidance concept. This simplified frequency sharing concept requires the Little LEO satellites to step or hop to the opposite NOAA MetSat band segment whenever a NOAA MetSat satellite coverage footprint overlaps that of a Little LEO satellite horizon. The coincidence times are readily precomputed and frequency selection instructions can be loaded into each satellite to span the duration of element set validity.

It should be noted that for a multiple satellite NOAA NPOESS system, the potential exists for two NOAA coverage zones to overlap a Little LEO horizon footprint over CONUS as shown in Figure 1. These coverage contours were obtained by using five of the NOAA satellites currently in orbit as representative of future orbital coverage. This overlap will result in total blockage of the Little LEO System in those areas where the dual NOAA overlap occurs. Worse still, any two NOAA satellites within the horizon coverage of a Little LEO satellite will potentially result in a blockage situation. This worse case analysis assumes the two NOAA MetSats in close proximity will use both portions of the bands or channels so as not to interfere with themselves, leaving a Little LEO without any available spectrum during this overlap period.

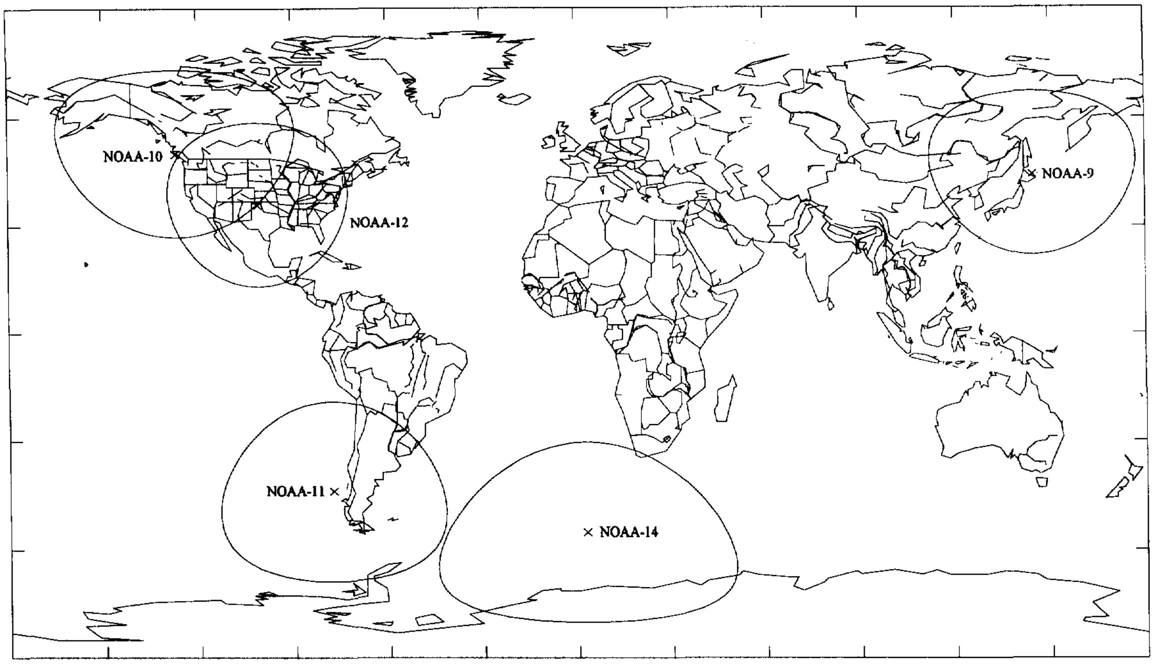

Figure 1. Five Satellite NOAA Constellation Coverage For 5° Elevation Footprint.

Figure 2 is a plot of Leo One USA's availability calculated for sharing of the NOAA bands or channels with a 2, 3, 4 or 5 POES satellite constellation. The NOAA-14, NOAA-12, NOAA-11, NOAA-10, and NOAA-9 satellites were used for this availability calculation. The NOAA-14 (137.620 MHz) and NOAA-12 (137.500 MHz) satellites being the current two AM & PM operational satellites. The others are currently in standby and are used in the order listed as representative of future NOAA constellation growth. NOAA-K is planned to replace NOAA-12 in August 1997. The launch dates for the planned replacement satellites are NOAA-L (PM) in Dec. 1999, NOAA-M (PM) in April 2001, NOAA-N (PM) in Dec. 2003 and NOAA-N' (PM) in July 2007. These last two N-series satellites being the new LRPT band satellites. The European METOP-1 and -2 satellites are planned as AM satellites for 2002 and 2006 and will use the new LRPT bands.

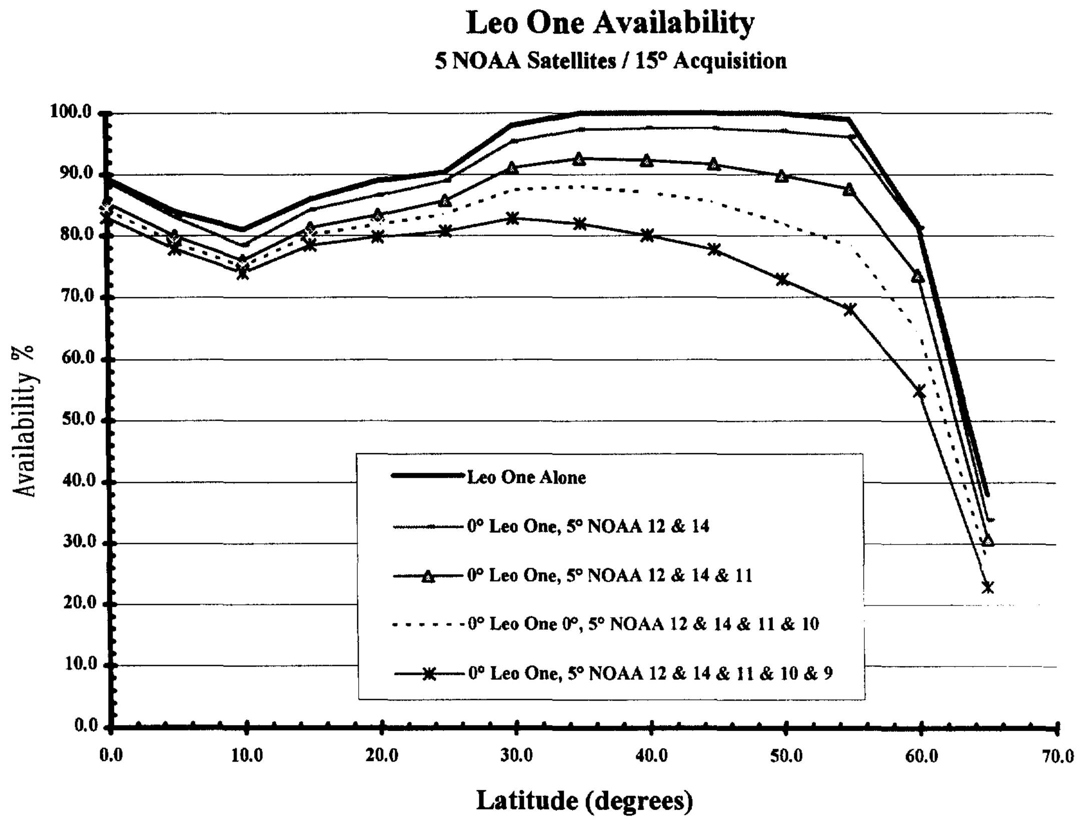

Figure 2. Availability As A Function of The Number Of NOAA Satellites.

The current Meteor-3 series of Russian MetSats may cause some interference at the edges of the TIP channels. Likewise, the China FY-1B satellite currently overlaps the upper TIP NOAA channel and also the lower LRPT band. For this analysis, it is assumed that availability degradation is insignificant.[1] Russia has indicated that beginning with its second Meteor 3M series it will transition to the LRPT bands[2]. The first Meteor 3M satellite will continue to use the existing Russian channels at 137.30, 137.40, and 137.85 MHz. The Meteor 2 system previously used 137.15 MHz instead of 137.85 MHz. Their continued use of the 137.30, 137.40, and 137.85 MHz bands after their transition to the

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1 This cannot be verified. It is assumed that these systems would transmit worldwide.

2 Russian Fax OMPZ-50-06967 to FCC Notifications Branch Dated July 1995.

LRPT bands is unknown. If they are planning to vacate these bands, additional spectrum may be available on an exclusive basis. This would significantly improve availability and capacity over that computed here. It is believed there currently are three active Russian MetSats, Meteor 3-5 (137.850 MHz - ATP signal), OKEAN 1-7 (137.400 MHz - ATP signal), and SICH-1 (137.400 MHz - ATP signal).

In using Figure 2 to interpret the availability when using the TIP channels, it is assumed the TIP signal is on continuously. It's usage when not in-view of a CDA station is not clear. If this transmission ceases when not in-view of a CDA station, then the potential availability increases dramatically except around CDA stations. These calculations assume a 5° elevation coverage footprint for the MetSats to a 0° horizon coverage contour for calculating the exclusion zone for Leo One USA transmissions. The Leo One USA communications coverage is computed for an elevation angle of 15°. Since Leo One USA is the largest Little LEO constellation, other Little LEO systems should experience less reduction in availability than Leo One USA.

Leo One USA requires eight 25-kHz downlink subscriber channels (200 kHz) and three 50-kHz gateway channels. The total bandwidth requirements for the downlinks is 350 kHz of spectrum. The shared use of the LRPT bands provides 300 kHz of somewhat exclusive spectrum (except for China's FY-1B) until 2002; the shared use of the TIP bands could provide an additional 120 kHz which would then meet Leo One USA's requirements most of the time[3].

If Leo One USA was to share the LRPT and TIP bands, but avoid Starsys, as suggested by the Notice, a total of 420 kHz is available. Initially, when one existing MetSat is overhead, half the TIP spectrum is available or 360 kHz. When two satellites are over head, none of the TIP spectrum may be available or 300 kHz total would be available. However, the TIP bands may not be used by all of the satellites. Again, Leo

[3] If the APT bands, referred to in the Notice as being reserved for Orbcomm, were allocated to new licensees an additional 60 kHz would be available for exclusive use after 2006.

One USA needs 350 kHz to service all its requirements. Thus, for some small period of time a gateway channel could be turned off. This would be acceptable. Occasionally when the China MetSat is overhead a 50 kHz portion of the LRPT band would be unusable because of interference. Thus, at times, only 250 kHz may be available. This would be sufficient for subscriber communications and a single gateway link which would provide satisfactory utility for this limited triple conjunction period.

The Commission in the Notice has indicated it intends to move Orbcomm out of the 137.185-137.2375 band segment to the NOAA ATP channels, obstensively to avoid interference with NOAA's use of the LRPT band. Under this plan it appears that Orbcomm will end up with 290 kHz of exclusive downlink spectrum. The timing for the transitioning to the ATP bands is unclear and will block significant spectrum that otherwise would be useful. In order to accommodate this transition, Orbcomm should move immediately and time share the ATP bands with NOAA just as the TIP bands must be time shared with any new second round entrant. When NOAA begins usage of the LRPT bands in 2002 (METOP), the ATP bands must continue to be shared for a number of years until the then existing NOAA satellites all fail (probably 2007). Alternatively, Orbcomm retains its current spectrum freeing 60 kHz for supporting additional second round entry. If Orbcomm is allowed to transition to APT but at its own pace then presumably when the NOAA satellites using the ATP bands cease all operations, Orbcomm would transition into these bands. This has a likely target date of 2007 or later. By that time, a Little LEO sharing the LRPT bands will effectively be transitioning out as well because of the large constellations of Metsats using the band; presumably they must transition into the spectrum left vacant by Orbcomm or else face diminished capacity.

At this point there would exist at most 120 kHz of exclusive TIP spectrum with the diminished capability to share the LRPT band and if the spectrum vacated by Orbcomm could be used, an additional 92.5 kHz of exclusive spectrum is potentially available from 137.1825 to 137.275 MHz.

Should Meteor 3 vacate it's bands an additional contiguous 50 kHz may open up in addition to another 42.5 kHz segment. Potentially this provides a gateway and at least four additional dedicated TSD channels, if the Russians co-operate. Some lesser channel bandwidth of the order of 20 kHz are also also potentially available.

In total, in the Post 2006 time frame, there could be as much as 305 kHz of exclusive spectrum available but more likely just the 120 kHz of TIP channels.

We note that the Notice refers to the TIP channel as extending from 137.333 to 137.367 MHz rather than 137.320 to 137.380 MHz and 137.753 to 137.787 MHz rather than 137.740 to 137.800 MHz, which are consistent with the necessary channel width for the current NOAA TIP signals. The TIP signals have a necessary bandwidth of 44 kHz and a necessary channel width of 60 kHz. We have assumed the bandwidth available to a Little LEO would be consistent with the 60 kHz TIP channel bandwidth. The APT signals have a necessary bandwidth of 38 kHz. The necessary channel width includes allowances for oscillator drift and Doppler frequency shift and is 50 kHz. The LRPT signal is 72 kbps digital signal and requires a 150 kHz channel bandwidth.

a. Concurrent Time Sharing of TIP Channels and LRPT Bands

During the transition period when a Little LEO must share both the NOAA channels and the NOAA bands, the availability becomes a function of two sets of satellite constellations. One set operating in the LRPT bands and one set operating in the TIP bands. For this situation, it takes two satellites from each set to simultaneously be in contact with a Leo One USA satellite in order to fully block communications. For the purposes of evaluating this situation, an existing five satellite NOAA and an existing five satellite DMSP constellation were chosen as offering representative orbit coverages.

Figure 3 provides a snapshot in time of its world wide coverage. Using this worse case of five satellites each, the availability shown in Figure 4 was evaluated. As indicated, the user availability is high. It should be noted that the availability achievable can be increased to essentially 100 percent if additional dedicated spectrum is available for a subscriber downlink.

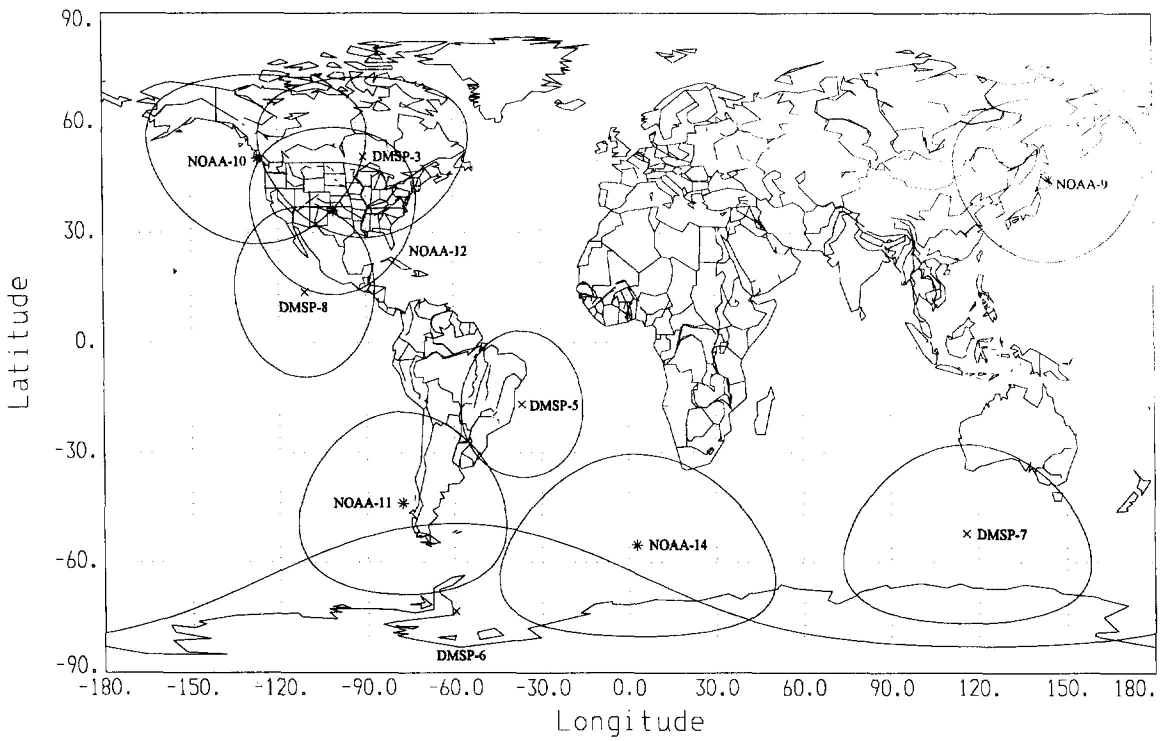

Figure 3. Extended MetSat Coverage For Transition Period Analysis.

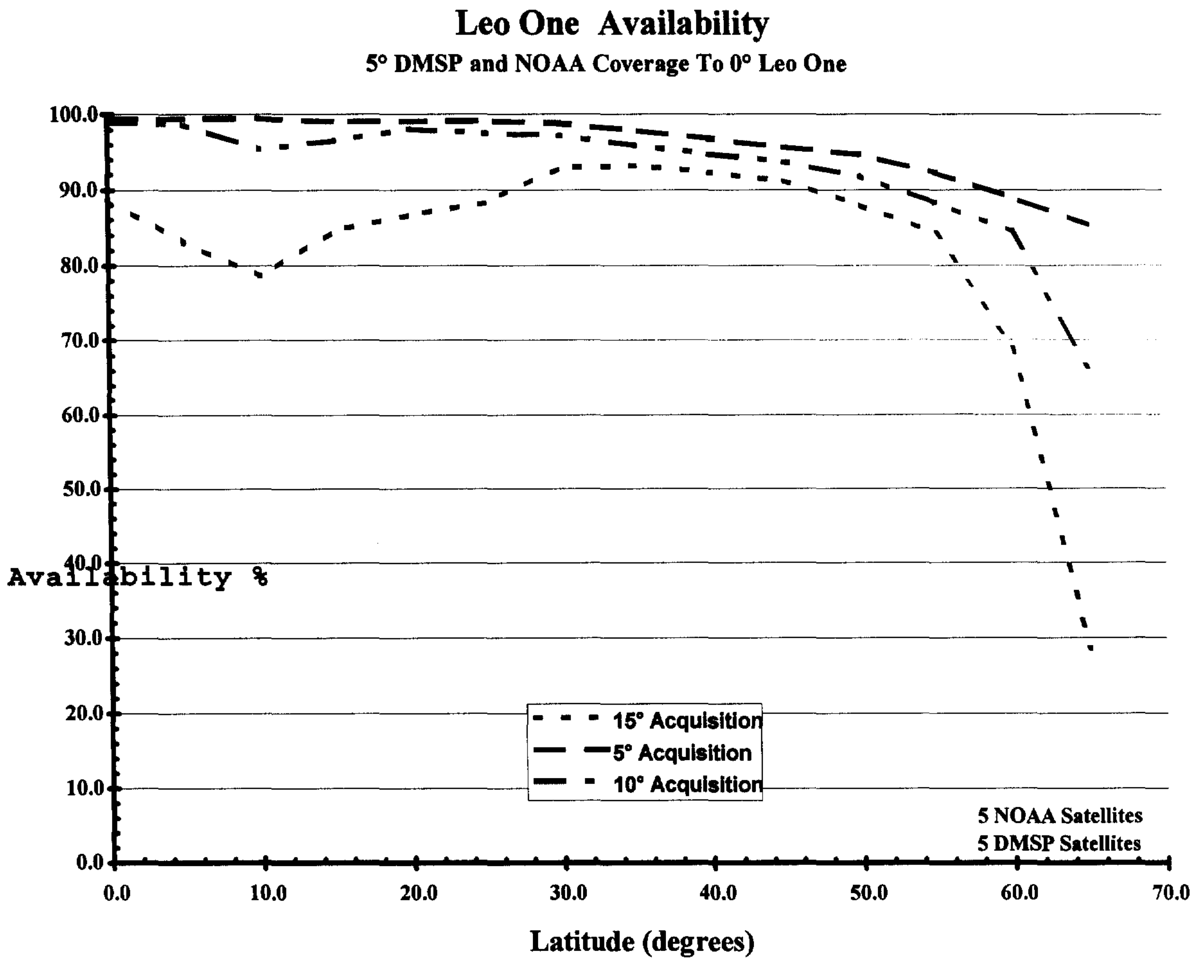

Figure 4. Availability When Sharing LRPT Bands With Five MetSats And TIP Channels With Five NOAA Satellites.

b. Impact on NOAA Community of Little LEO Transmissions When NOAA Satellites are Not in View

The NOAA satellite transmission formats and rates are sufficiently different from those of the proposed Little LEOs that NOAA receivers should not respond to the Little LEO signals. Likewise, Little LEO receivers will not respond to NOAA transmissions due to the different modulation formats and data rates. While a Leo One USA receiver may attempt acquisition of a NOAA signal carrier, the Little LEO receiver will not respond due to the lack of a CRC check sum validation, even if data rates were the same, just as it will not respond to noise signals. In this manner, its operation is transparent to the user.

The NOAA primary instruments are the Advanced Very High Resolution Radiometer (AVHRR) and the TIROS Operational Vertical Sounder (TOVS) complex. The APT modulation format is AM on a 2.4 kHz subcarrier which in turn frequency modulates the carrier. This signal operates at either 137.50 or 137.62 MHz. Eventually, these APT signals will be moved to 137.1 and 137.9125 MHz. The NOAA Analogue Picture Transmissions (APT) signals have a necessary bandwidth of 38 kHz. The necessary channel is 50 kHz which includes allowances for oscillator drift and Doppler frequency shift. The transmitter power is 5 watts into a RHCP quadri filar antenna with 0 dBci at the horizon and +4.5 dBci at nadir. This signal modulation format is unlike the more modern digital formats proposed by Little LEO applicants.

By the year 2006 the NOAA NPOESS series satellites will be launched with the APT replaced by the Low Rate Picture Transmission (LRPT) digital signal. The LRPT is a 72 kbps digital signal and requires a 150 kHz channel. Leo One USA believes this is a BPSK signal format. This data rate is much higher than proposed by any of the Little LEO systems. Thus, it is unlikely an LRPT receiver would respond to a Little LEO signal.

The Tiros Information Processor (TIP) telemetry data transmits at 137.35 and 137.77 MHz. The TIP signal has a necessary bandwidth of 44 kHz and a necessary channel width of 60 kHz.

c. **48 Hour Reset Signal is Unnecessary**

The need for a 48 hour reset signal seems arbitrary and unnecessary. We assume this requirement is to ensure that the satellites are healthy and functioning properly. We do not plan that every gateway have the ability to command our satellites. While we would plan to communicate with the satellites in our constellation routinely, consistent with our orbit repeat cycle, we believe the ephemeris data necessary to ensure operation outside NOAA exclusion zones will be valid for at least seven days. Thus, we do not see the need to communicate with every satellite every 48 hours. We would intend that if a satellite had not heard from its command center within seven days in order to receive a new set of ephemeris exclusion zone data, that it would then cease transmissions until such time that a valid upload is received.

Should a satellite fail, the ground network of gateways would presumably detect this situation and report it well within any 48 hour period. If not, the NOCC command center would make this determination.

We would propose instead that a series of dual redundant fail safe procedures be implemented to ensure the satellite does not operate in a NOAA exclusion zone. These procedures can best be determined by each Little LEO system. For example, if the NOAA band transmitter failed to turn off, a transmit timer can be implemented to ensure that it is turned off, say, every rev with a modem off switch separate from a power amplifier power switch. Error protected memory with memory scrubbing can be used for critical command functions to preclude latchup or upset errors. Command encryption should be used to preclude tampering with the satellite operating modes. Command authentication should be implemented on each command before execution, watch dog timers should be implemented on key control computers, etc. These are all things any prudent, reasonable and professional satellite designer would implement in the normal course of a design. While Leo One USA's satellites may be small, they hardly lack in sophistication. The successful operation of the satellites, the constellation, and the ability to provide reliable services require high quality and reliability of the space segment.

We plan to shut our satellite transmitters off automatically during idle periods to conserve prime power. Thus, we expect the transmitters to be off a significant portion of the time, especially over ocean areas. To ensure against latchup situations where the transmitter might otherwise be stuck on, we intend to implement a fail-safe timer as alluded to above. The exact time duration remains to be determined, which will be based on the average power budget for the satellite. At this time we believe a one rev cycle time will be satisfactory.

The impact of a Rogue Leo One USA satellite is shown in Figure 5. Here we define a Rogue satellite to be a satellite with its transmitter stuck on such that it will interfere with a NOAA/DMSP satellite. We note that the impact of a Rogue satellite to the DMSP user availability is less than 0.5 percent as shown in Figure 5. We note that the corresponding percent of the time that the Rogue satellite interferes with a ground DMSP/NOAA user as a percent of a NOAA pass is less than 6.7 percent, assuming a five NOAA/DMSP satellite constellation. Because of the low frequency of interference, the imposition of a 48 hour timer reset does not seem justified. Rather, prudent design decisions as discussed above should suffice.

More over, with doubly redundant fail-safe methods and typical electronics reliability (probability of failure of less than 0.001 over 5 years), it is straight forward to show that the probability of the Rogue event due to failure as shown in Figure 5 is less than 5 $\times 10^{-8}$ in five years for the entire Leo One USA constellation. Because of the low probability of this Rogue Satellite interference, the imposition of a 48 hour timer reset does not seem justified and better left to the satellite designers.

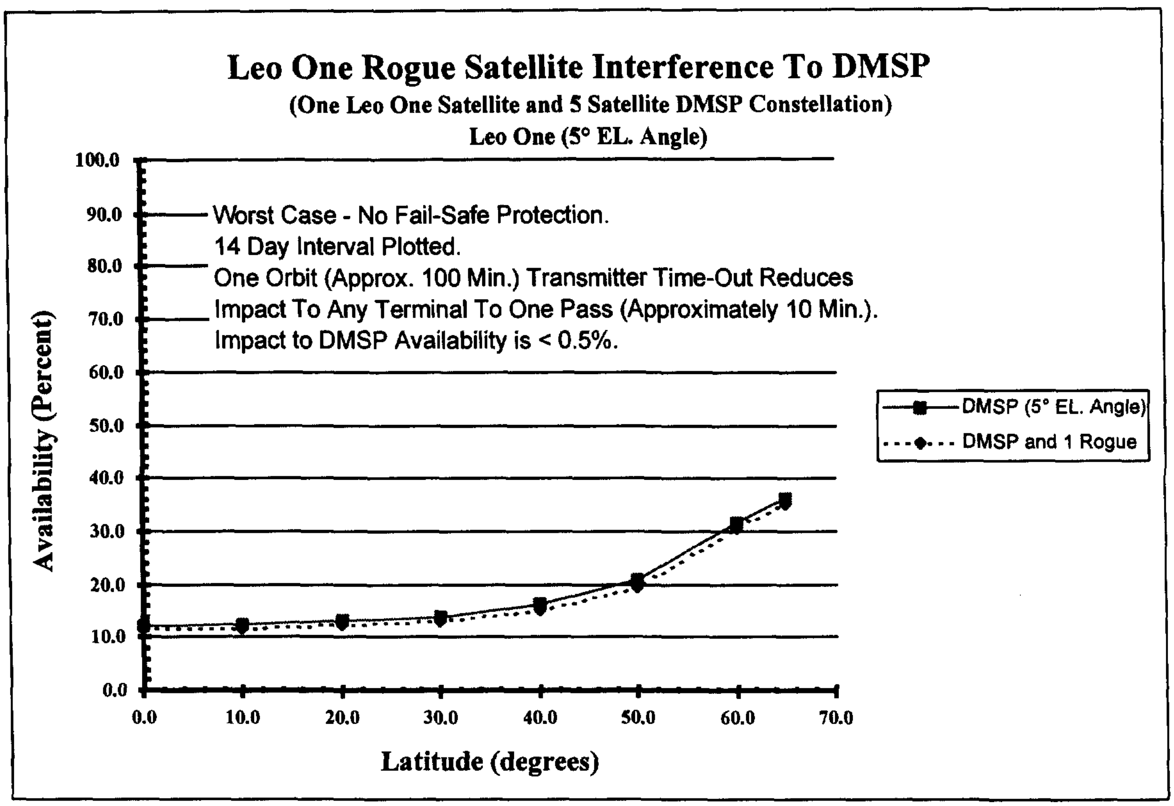

Figure 5. Impact of Rogue Satellite on NOAA/DMSP Availability.

If such a timer is required, it can be verified on orbit during an initial test and checkout phase. It can also be verified through inspection of the build documentation. We would not like to see our operations interrupted for periodic on orbit testing. The impact to NOAA is so slight that we view this as an unjustified imposition.

D. Metsat Earth Stations Operating at 137 - 138 MHz Should be Protected Only While the Associated Satellites are Located at Elevation Angles of Five Degrees or Greater

Consistent with applicable functional requirements, performance factors, and international frequency sharing criteria, meteorological earth station receivers operating at 137-138 MHz and 401.5 - 401 MHz should be protected only while the satellites are at elevation angles of 5 degrees or above. There generally are no functional requirements to receive "direct readout" data[4] from meteorological satellites at elevation angles less than five degrees because the associated geographic areas are too limited and distant to indicate current and evolving meteorological conditions. Even if reception of data at lower elevation angles were desired, NOAA transmissions cannot be reliably received below 5° to 10° elevation due to multipath and local obscura just as a Little LEO's transmissions would not be reliably received. Accordingly, a minimum elevation angle of five (5) degrees has been specified for interference and frequency sharing criteria adopted internationally for meteorological-satellite earth stations. Reference Appendix D for a discussion of the ITU recommendations.

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[4] "Direct readout" data consists of the data that are collected by sensors on the satellite and transmitted in real-time.